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Research paper

Performance parameters of protocol AOMDV under random obstacle mobility model

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Abstract

A Mobile Ad Hoc Network (MANET) is a collection of mobile nodes that are dynamically self-configured, with no physical infrastructure nor centralized administration. In this article, we discuss which of the routing strategies for MANETs: proactive, reactive or hybrid, has a better performance. For the measurement, we have established thirty-six simulation for emergency scenarios in an urban area. This involved, in addition to quality of service (QoS) parameters defined, the calculation of the node densities and the usage of a mobility model needed to validate the results. These must determine which routing protocol has better QoS under the Random Obstacle Mobility Model. The simulator using was NS2 version 2.35.

Keywords: *Ad Hoc Networks; AODV; AOMDV; DSDV; MANET; QoS; Random Obstacle Mobility Model.*

1. Introduction

A MANET is a collection of autonomous mobile nodes communicating; there is no fixed network infrastructure. In this environment, nodes are involved in decision-making, performing maintenance duties and taking part in routing algorithms. In general, any proposal applicable to a MANET must take into account the constraints imposed by the inherent characteristics of these networks. These characteristics are defined in [1] and they are: dynamic topology, limited bandwidth links, energy constraints [2], physical security constraints [3], and processing capacity of the nodes. So far, research efforts have primarily focused on routing issues. Considering that routing is one of the most important mechanisms in MANETs, others like QoS provided or security and service discovery, cannot be executed if there is no optimal communication link [3]. Boost of new applications has enabled more people to use and take advantage of smart devices o smartphone[4]. Users understood as nodes in the MANET, work inside a set of elements denoted scenario. A scenario is composed of a particular number of nodes, topography and a mobility algorithm, which includes direction, speed and pauses of those nodes. In case of a real scenario, the topography is haphazard due to the amount of obstacles arising from undesired events that cause the alteration of usual mobility pathways. Therefore, the motion algorithm is determined according to the topography and the corresponding nodes that must be displaced depending on the obstacles. The number of nodes depends on the MANET network and of course [5], if it is in an urban or in a rural area. When there is a non-planned event, normal mobility routes change, and new rescue and evacuation routes are recalculated. The main objective of this work is to determine which of the Ad Hoc strategies reviewed, has a better performance. For the comparative analysis on QoS parameters [6], we chose one routing protocol from each of the following groups:
Proactive, Reactive and Hybrid [7] [8]. The simulation was performed for any urban area, under the Random Obstacle Mobility Model, for twenty-four scenarios, and with help of the NS2 (Network Simulator version 2) tool [9].

2. Related work

The types of routing protocols analyzed in this research paper are broadly described next.

2.1. Routing protocols

Proactive routing protocols maintain information on all routes throughout the network, even if they are not required, so each node can have them registered [10]. Generally, these protocols exchange control information between nodes to keep updated routing tables in the entire network [11]. They also react when a new node appears or when another node is no longer within the network topology. Most known proactive protocols are: Destination-Sequence Distance-Vector (DSDV) [12] and Optimized Link State Routing (OLSR) [13].
The DSDV protocol [12] solves the major problem associated with distance vector routing of wired networks i.e., Count-to-infinity, by using destination sequence number. The DSDV protocol requires each mobile station to advertise to each of its current neighbors. However, this protocol requires each node to maintain routing tables. These routing tables cause a significant amount of memory overhead at each node as the size of the network increases.

Optimized Link State Routing (OLSR) [13] is a point-to-point protocol based on the traditional link state algorithm. In this protocol, topology information is periodically exchanged by using of link state messages. The advantage of OLSR is that it minimizes the size of each protocol message and the number of re- broadcasting nodes during each route update by employing multipoint replying strategy.

As mentioned above, when a change occurs, updates are propagated through the network to keep routing tables on day. It is an ongoing assessment of the routes between nodes. However, these acts can cause serious overloading in the network, affecting the utilization of bandwidth, performance and energy [2]. In static topologies, this routing scheme can work properly, but for highly dynamic topologies, not manage the network gives it a good scalability [14].

Reactive routing Reactive routing protocols only allow on-demand updating of the tables. For example, when a unique node wants to exchange information in the network. An on-demand routing protocol typically includes two components:

- **Route Discovery**: If the source does not have the route towards the destination in its current routing table, it broadcasts a route discovery packet throughout the network. Once the route between the source and destination has been established, the data could be transmitted through the selected route.
- **Route Maintenance**: Due to the dynamic nature of MANETs, failure of the links through the route may happen.

Route maintenance is a mechanism to handle the route breaks. A node can confirm if a packet is correctly received on its downstream node (backward Route), by using any of the three types of acknowledgments: link-level, passive (listening to the forwarding by next-hop node), and network-layer. Among the most known reactive protocols are: Dynamic Source Routing (DSR) [15] and Ad Hoc Demand Distance Vector (AODV) [16] [7]. The Ad hoc on Demand Distance Vector (AODV) [17] routing protocol is based on DSDV and DSR [15] [18] [19] protocols. It provides unicast, multicast, and broadcast com- munication. It uses the periodic beaconing and sequence numbering procedure of DSDV and a similar route discovery procedure as used in DSR. However, there are major differences between DSR and AODV. The most distinguishing feature is that in DSR each packet carries full routing information whereas in AODV the pa-ckets only carry the destination address meaning that AODV has potentially less routing overheads than DSR [18]. DSR protocol requi-res each transmitted packet to carry the full address from the source to the destination likewise the mechanism used in AODV. This me-chanism in DSR makes it not to perform effectively in large networks, since the amount of overhead carried in these packets is increased dramatically as the size of network grows [15] [20]. Hence, in highly dynamic and large networks the overhead may consume a large amount of bandwidth. However, this protocol has a number of advantages over routing protocols such as AODV and TORA (Temporally Ordered Routing Algorithm) [21] and in small to moderately size networks, this protocol performs markedly better. Hybrid routing This sort of routing combines reactive and proactive features. For our specific case, within this classification we find the AOMDV routing protocol, AODV extension, which allows calculating several disjoint paths without loops and without links. AOMDV [22] can be used to find node-disjoints or link- disjoint routes. To find node-disjoint paths, each node does not reject duplicate RREQs immediately. Each Route Request (RREQ), which arrives via a neigh- bor different from the source, defines a path of node-disjoints. This is because the nodes cannot broadcast duplicated RREQs, so any RREQ arriving at an intermediate node through a neighbor, could not have passed through the same node. In an attempt to get multiple link-disjoint paths, the destination responds duplicating RREQs. After the first jump, Route Replies (RREPs) traverse the return paths that are node-disjoints and therefore link-disjoints. The trajectories of each RREP can be cut at an intermediate node, but each one of them has a different return path to the source for ensuring link disjunction [23] [22]. The advantage of using AOMDV is that it concedes intermediate nodes to respond to RREQs, while disjoint paths are still being screened. However, AOMDV has more overhead messages during the route discovery, since it is a multipath protocol and it suffers increased floo-ding.

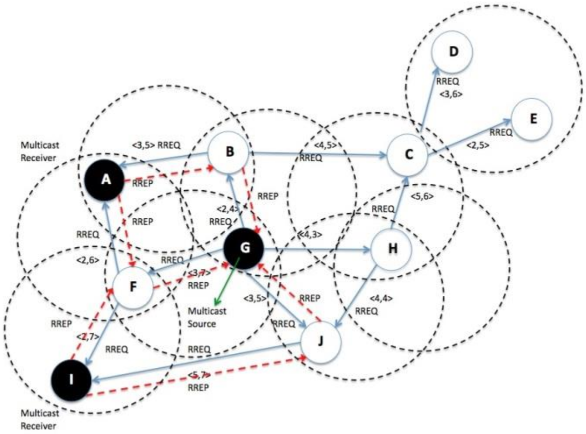


Fig. 1: Communication Routing Protocol AOMDV in the Ad Hoc Networks.

Figure 1, shows components and communi-cations process of a hybrid routing protocol AOMDV.

2.2. Mobility models

One of the most used methods for evaluating the characteristics of Ad Hoc routing protocols is through simulation. With simulation we obtain a number of significant benefits including: repeatable scenarios, removal or changes of pa- rameters, and exploration of a variety of metrics. Once the nodes are set in a certain area, the mobility model governs the displacement of the nodes within the network [24 - 26].

In general, the mobility model can be categorized either as a synthetic mobility model or as a based-on-traces mobility model [27]. In the synthetic mobility model, nodes move according to certain rules and equations. Moreover, the nodes in the based-on-trace mobility mo-del are sustained on information of real trace files. These files are obtained by tracking the mobility of nodes in real scenarios. The synt-hetic mobility model has attracted much attention in recent decades because of its simplicity. Taking this particular type of mobility mo-del, the Ad Hoc network's performance has been evaluated under different patterns [27]. So far, the Random Waypoint Mobility Model is the most used one in Ad Hoc networks. However, it is not accurate for real-life scenarios. The nodes do not follow a uniform density, as the central positions are heavier than others. That's why for the simulation of the analyzed routing protocols AOMDV, DSDV and AODV, we used the Random Obstacle Mobility Model, which looks for a big range of possibilities for your next move.

In this mobility model, obstacles are randomly distributed in an urban area, which for simulation purposes, would interfere with the normal process of communication between nodes.

The purpose of this model is to obtain a real approach for the movement of an Ad hoc network operated by humans, to apply it in various fields such as disaster areas by earthquake, fire, etc., where rescue teams such as doctors, firefighters, police and more, are facing a stage full of obstacles. The X node first sets i as the start point of mobility and f as the destination, then it analyzes the vertex so_1 and so_2 from the nearest obstacle from f node, which is SO. In case this vertex is inaccessible due to a SO obstacle, the node selects a vertex fo_4, nearest to obstacle FO and to the so1 vertex from SO. This is done until reaching your destination f, as shown in Figure 2.

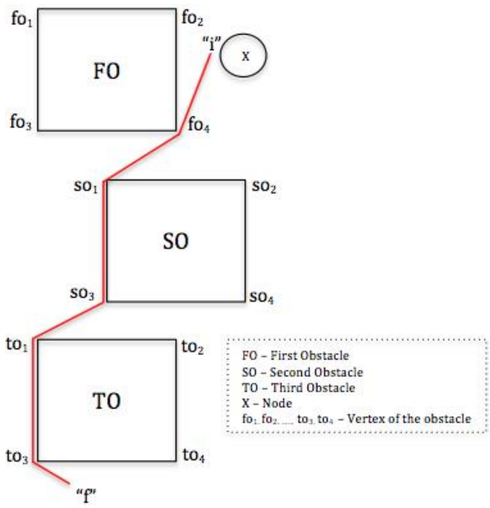


Fig. 2: An Example of the Random Obstacle Mobility Model.

We have seen how the mobility model used in this simulation of routing protocols shows a realistic behavior of people around obstacles. When a person moves to a particular point, it is reasonable to assume that he will try to go dodging the obstacles in the way, to reach the desired destination, even if at the end, this is not the most optimal path in terms of the total distance. In most cases, obstacles are unknown for a person moving in those areas. Below is the process architecture considering all components from the beginning of the simulation, to the results here discussed (Figure 3).

At next, we will set the variables to simulate scenarios, starting with the calculation of the node densities in an area of 1000m x 2000m (Figure 4).

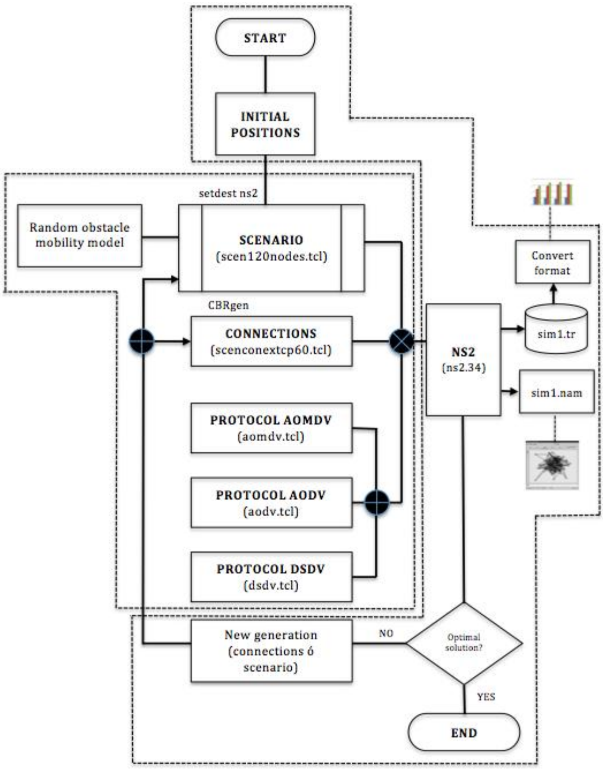


Fig. 3: Process of Simulation of Protocols under Random Obstacle Mobility Model.

3. Proposed scenario

3.1 Simulation process of real scenario chosen and node density calculation

The calculation of the node density Pnode is supported by information obtained from the Ecuadorian census in 2010. An important factor for the calculation of the node density is the percentage of the Economically Active Population (PEA). To calculate the density of nodes the following equation has been proposed [6] [28].
We found that Pnodes0 , Pnodes2 and Pnodes3 are 90, 120 and 150, respectively. The node densities for simulation are: Pnodes0 = 90, P_{nodes1} = 97 , P_{nodes2} = 120 and P_{nodes3} = 150.

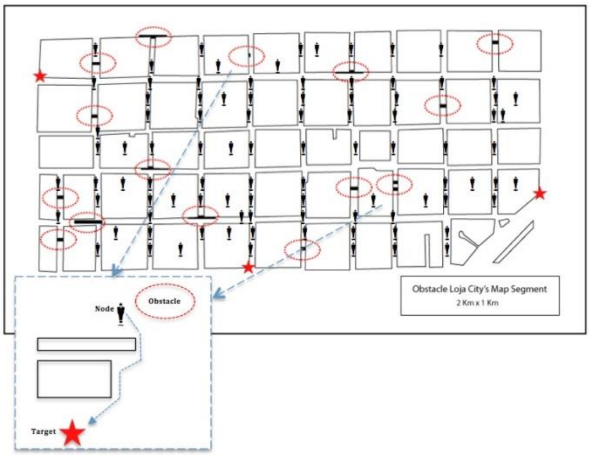


Fig. 4: Random Obstacle Mobility Model in Area 1000m X 2000m.

3.2. Creating scenarios

Using a terminal, we entered the following directory: ns-allinone, then we ac- cessed ns2.35/indeputils/cmugen/setdest/setdest, in order to create a scenario of 120 nodes with the following command ./set- dest-v 120-2-n-m 2 s 1 m 6-t- 150-P-1-p 2 x 2000-and 1000. The sample was successfully created and named Scenario1. This should be replicated to the other scenarios we need to create. In the com- mand shown: run-v 2, which is the scenario generator version; we identify: n, which means the number of nodes; s, is the kind of speed (1 = Uniform); minspeed, represented with lowercase m, is the minimum speed in m/s; maxspeed, represented with uppercase m, is the maximum speed in m/s; -t, indicating the simulation time in seconds; -P is the pause time simulation in seconds; maxX, the size in meters for the X dimension; maxY, the size in meters for the Y dimension; and finally [outdir = file], Filename motion itself scenario name. The directory should be reopened to verify the creation of all scenarios.

3.3. Creating connections

First, we entered ns-allinone, then, the next route is ns2.35/indeputils/cmugen/setdest/. In this direction, the cbrgen.tcl file is located, this file serves me as a basis to create the connections, it should be emphasized that for this scenarios we created two types of connections 30 and 60 for the amount of 90, 97, 120 and 150 nodes. To generate the connections, we accessed via a terminal ns2.35 and executed the following command: ns cbrgen.tcl-type tcp-nn 120 seed-mc 30-rate rate 2 > scenconextcp60. Where: tcp -, is the type of traffic; nn -, indicates the number of nodes in the simulation; seed, random seed; mc -, connections number of con- nections; - rate, indicates the baud rate in pkts/sec; and finally [outdir=file] that becomes the file name connections.

3.4. Characteristics and performance metrics of routing protocols in MANETs

Commonly, there are four main metrics presented in [29] as parameters of QoS which are dropped packet (or packet delivery ratio), delay (route latency), jitter (delay variance), and bandwidth. Table 1, provides a list of popular qualitative and quantitative properties and cha- racteristics of MANET routing protocols. [30] [31]. Some of the metrics in [31] are applied to compare proactive and reactive routing protocols in terms of overhead, scalability, and loop-freedom. The purpose of referring to performance metrics in this paper is to correla- te proac- tive, reactive and hybrid protocols according to these metrics. Considering that some publications have contrasted routing pro- tocols using the packet delivery ratio, control overhead, hop count, and end-to-end delay, the performance of routing protocols in this paper is mostly evaluated in terms of: delay, jitter and dropped packets with random obstacle mobility model. To define the simulation scenarios we used the same basis as in [36] [37]. Each one of these values are shown in the Table 1.

Table 1: General Parameters and Characteristics for the Simulation of AODV, DSDV and AOMDV Protocols

Parameter	Value	Observations and related works
Simulation area	1000m x 2000m	Area established within the center of the city of Loja
Mobility model	Obstacle Models (Fig.4)	Obstacle models [32, 33]
Number of nodes	90, 97, 120 and 150	To determine the behavior of protocols for different node densities
Number of connections	30, 60	random connections
Time of simulation	150	seconds
Network layer protocols	AOMDV[22],[34, DSDV [35] and AODV[16]	Proactive and reactive protocols

Table 2: Variables and Parameters in the Script for the Simulation of Protocols AODV, DSDV and AOMDV

Variable	Value	Observations
set val(chan)	Channel /Wireless- Channel	Channel Type
set val(prop)	Propagation /TwoRayGround	Radio propagation model
set val(netif)	Phy/WirelessPhy	network interface type
set val(mac)	Mac/802.11	MAC type

set val(ifq)	Queue/DropTail /PriQueue	interface queue type
set val(ll)	LL	link layer type
set val(ant)	Antenna/ Omni- Antenna	antenna model
set val(ifqlen)	100	max packet in ifq
set val(nn)	150	number of mobile nodes
set val(rp)	AODV	routing protocol
*set val(rp)	AOMDV	routing protocol
*set val(rp)	DSDV	routing protocol
set val(x)	2000	area
set val(y)	1000	area
set val(conexiones)	“connectionstcp30”	connections
set val(scenario)	”scenario120nodes”	scenario
set val(stop)	150	time simulation

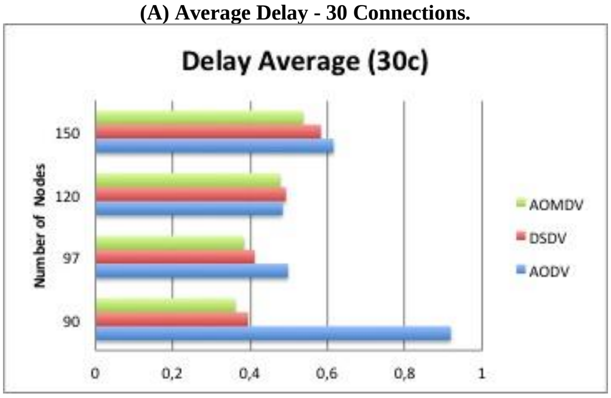
In order to analyze results and measure behavior of protocols, we selected some indicators from [30][38]. These indicators are: performance, protocol overhead, packet dropped, average delay and the variation of the delay or jitter. They are all compared with those of the following protocols: AOMDV, AODV and DSDV.

4. Simulation results

The NS2 simulator [9] is used to determine protocols attitude with the data shown in Table 1. In order to determine which one is the best protocol, we treated the following indicators:

- **Average delay**. This is very significant to measure for our purpose, because there is a need to send and receive network management information as soon as possible. With 30 connections, and with 120 and 150 nodes, AOMDV protocol yields little delays. Instead, with 60 connections, the panorama changes to demonstrate a great advantage in AOMDV usage over AODV and DSDV. Collected data is shown in Table 3, Table 4, Figure 5(a) and Figure 5(b).

(A) Average Delay - 30 Connections.



(B) Average Delay - 60 Connections.

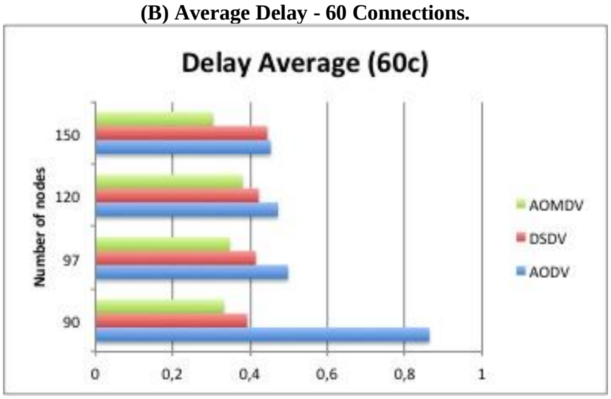


Fig. 5: Average Delay - 30 and 60 Connections with 90, 97, 120 and 150 Nodes.

Table 3: Delay Average - 30 Connections with 90, 97, 120 and 150 Nodes

Number of nodes	AODV(30c)	DSDV(30c)	AOMDV(30c)
90	0.918654	0.394391	0.361367
97	0.498009	0.411367	0.383271
120	0.483952	0.492132	0.477534
150	0.615480	0.582582	0.536986

Table 4: Delay Average - 60 Connections with 90, 97, 120 and 150 Nodes

Number of nodes	AODV(60c)	DSDV(60c)	AOMDV(60c)
90	0.863285	0.392374	0.331367
97	0.498023	0.414231	0.346918
120	0.471993	0.421802	0.379617
150	0.452916	0.444208	0.303840

- **Packet delay variation** - It is the difference or delay between end-to-end communication selected packets. In MANETs, it serves to measure convergence and network stability.

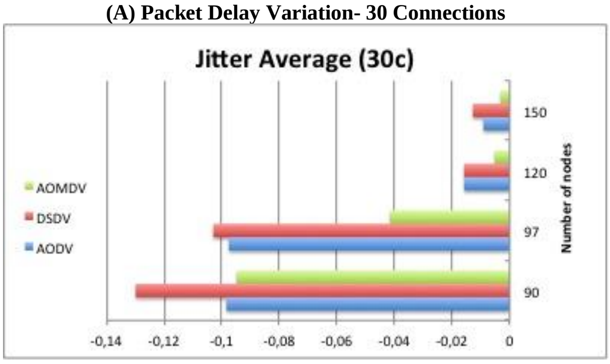
Table 5: Jitter Average - 30 Connections with 90, 97, 120 And 150 Nodes

Number of nodes	AODV(30c)	DSDV(30c)	AOMDV(30c)
90	-0.098328	-0.129873	-0.094765
97	-0.097499	-0.102874	-0.041516
120	-0.015795	-0.015821	-0.005149
150	-0.009072	-0.012745	-0.003136

Table 6: Jitter Average - 60 Connections with 90, 97, 120 and 150 Nodes

Number of nodes	AODV(60c)	DSDV (60c)	AOMDV(60c)
90	-0.941367	-0.124643	-0.027436
97	-0.114973	-0.102764	-0.033419
120	-0.088908	-0.085109	-0.027638
150	-0.084256	-0.079349	-0.019921

(A) Packet Delay Variation- 30 Connections



(B) Packet Delay Variation- 60 Connections.

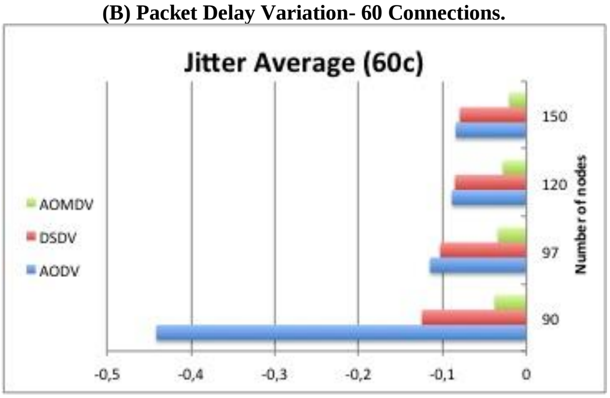


Fig. 6: Packet Delay Variation - 30 and 60 Connections with 90, 97, 120 and 150 Nodes.

This parameter is related to the mean fluctuation and helps us to determine which one of the three protocols would be the most appropria-te. The protocol with the lower jitter nearest to zero is the best, and it is the AOMDV. The simulation results are shown in Table 6, Table 5, Figure 6(a) and Figure 6(b).

- **Packet Dropped** - This is the amount of packets dropped by intermediate nodes due to the effects produced by its own continuous mobility, timer expiration, and unreachable destinations by Address Resolution Protocol (ARP).

Table 7: Dropped Packets - 30 Connections with 90, 97, 120 and 150 Nodes

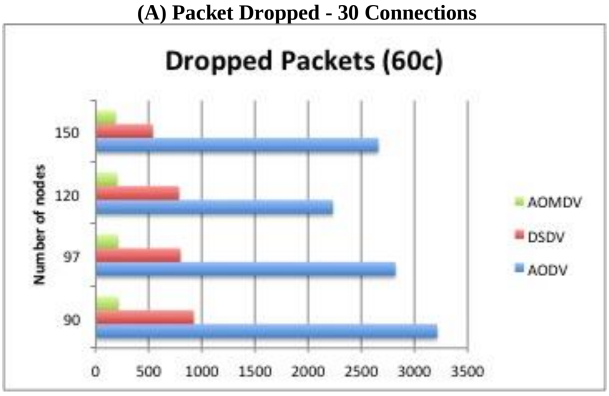
Number of nodes	AODV(30c)	DSDV(30c)	AOMDV(30c)
90	2543	863	314
97	2820	799	269
120	3207	631	245
150	2819	429	222

Table 8: Dropped Packets - 60 Connections with 90, 97, 120 and 150 Nodes

Number of nodes	AODV (60c)	DSDV (60c)	AOMDV (60c)
90	3214	921	211
97	2820	796	187
120	2206	751	196
159	2659	496	133

The purpose of this simulation is to set up which of the three routing protocols developed shows better QoS characteristics. According to the analysis, the protocol that removes fewer packets during transmission is the AOMDV protocol, both with 30 and with 60 connections. Data is shown in Table 7 y Table 8, Figure 7(a) and Figure 7(b).

(A) Packet Dropped - 30 Connections



(B) Packet Dropped - 60 Connections

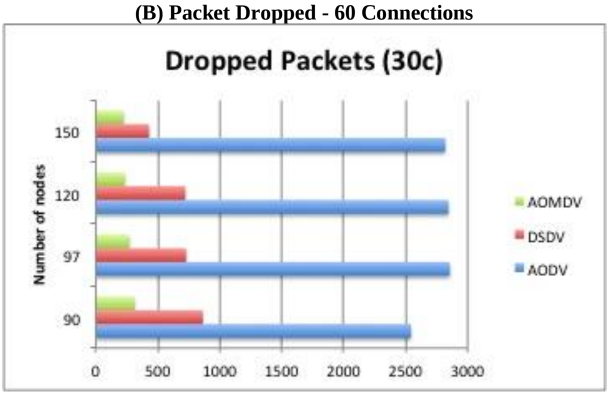


Fig. 7: Packet Dropped - 30 and 60 Connections with 90, 97, 120 and 150 Nodes.

5. Conclusions

- Mobility models are representations of human behaviors that require prior analysis and should be captured in all their dimensions. Later they are implemented on a certain area, with or without obstacles, and governed by parameters such as speed or time, among the most important.
- The Random Obstacle Mobility Model is a constant velocity model that grants QoS parameters to be analyzed reliably in routing protocols.
- Of the twenty four simulated scenarios under AODV, DSDV and AOMDV routing protocols, the one that has greater compatibility with the Random Obstacle Mobility Model, and best QoS characteristics at the communication time between nodes is the AOMDV.

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